COLOR CHANGES IN HPHT ANNEALED TYPE IA DIAMOND

F. De Weerdt

HRD (Diamond High Council), Hoveniersstraat 22, 2018 Antwerp, Belgium

Tel: +32/3/222.06.75, fax: +32/3/222.06.05, e-mail: fdw@hrd.be

H. Kanda

NIMS, 1-1 Namiki, Tsukuba, Ibaraki 305-0044, JAPAN

Phone: +81-29-859-2000 Fax: +81-29-852-7449, e-mail: HISAO.Kanda@nims.go.jp

Keywords: HPHT annealing,

Abstract

This investigation is focussed on the color changes, which can be obtained by HPHT annealing of type Ia diamonds. The color after treatment depends strongly on the presence of nitrogen and it's aggregation state and other defects like dislocations, … Specific attention is paid to nitrogen aggregation and dissociation kinetics, which play a major role in the resulting color after HPHT annealing.

Nitrogen as single substitutional atom and as aggregates plays a crucial role in the color of a diamond. These types of diamonds are called type I diamond. A further subdivision is made depending on the aggregation state of diamond: single substitutional nitrogen gives diamonds a yellow to orangy-yellow color and these diamonds belong to the subgroup Ib. If nitrogen is aggregated, then it is called a type Ia diamond. If the nitrogen is paired up (A defect), then the diamond will be colorless. Also, groups of 4 nitrogen atoms around a vacancy (B defect) do not absorb light in visible region of the electromagnetic spectrum and thus do not color the diamond. Groups of three nitrogen atoms around a vacancy (N3 defects) give the diamond a typical yellow color, a so-called Cape Yellow color.

A systematic study of diamonds containing various types of nitrogen aggregates (type IaA, type IaB), and also diamonds containing platelets, indicate that the most stable defect is the B defect. Other defects can dissociate in its components: the A defect can dissociate in two single substitutional nitrogen atoms and the activation energy is ~ 7 eV [1].

In brown diamonds, there are other types of defects present, which can dissociate. The brown color of these diamonds is thought to originate from dislocations and these dislocations generate vacancies during HPHT annealing. It is found that the activation energy for vacancy generation in brown type Ia diamond is also equal to ~ 7 eV [2].

CL imaging, using a scanning electron microscope, can detect regions with high density of dislocations in plastically deformed diamond. A suitable region for a line scan is selected on a polished (100) surface of a natural and HPHT annealed brown type Ia diamond. A spectral region between 365 and 630 nm was selected which allows clear identification of the presence of N3 with a zero phonon line at 415 nm and H3 with a ZPL at 503 nm. In untreated brown type Ia diamond, a number of other defect can also be detected at 490.7 nm, which is thought to be related to the plastic deformation [3]. The line scans clearly indicate that the H3 and H4 and 490.7 nm defects are located close to regions with plastic deformation in the diamond. CL line scans in the HPHT treated diamond clearly indicate that the vacancies are generated close to the dislocations, which gives a larger concentration of H3 defects close to the plastically deformed diamond.

The measurements on samples, which have been subjected to multiple HPHT annealing runs, suggest that vacancy clusters decorate dislocations and act as source of vacancies during HPHT annealing. These vacancies can be trapped at various nitrogen aggregates, giving rise to a large concentration of H3 defects. This large concentration of H3 defects is typical for HPHT annealed brown diamonds.

REFERENCES

1. F. De Weerdt, A.T.Collins, "The influence of pressure on high-pressure high-temperature annealing of type Ia diamond", *Diam. Rel. Mater.*, Vol. 12, 507-5, (2003).

2. F. De Weerdt, R. Galloway, A. Anthonis, “Defect Aggregation and dissociation in type Ia diamonds by annealing at high pressure and temperature (HPHT) ", *Defect and Diffusion Forum (Annual Retrospective - Ceramics VI)*, Vol. 226-228, , p. 49-60, (2004).

3. A.T. Collins, H. Kanda, H. Kitawaki, “Colour changes produced in natural brown diamonds by high-pressure, high-temperature treatment”, Diam. Rel. Mater., Vol. 9, p. 113-122, (2000).